DOCUMENT RESUME

ED 025 099 EF 001 823

By- Valvoda, Frank R.

School Heating - Gas vs. Electric. Phase 1A - Effect on Construction Costs. (Updating Phase 1 Report Dated January 1965).

Northern Illinois Gas Co., Aurora, Ill.

Pub Date May 68

Note- 60p.

EDRS Price MF-$0.50 HC-$3.10

Descriptors- Component Building Systems, *Construction Costs, *Educational Facilities, *Elementary Schools, *Heating, *School Buildings

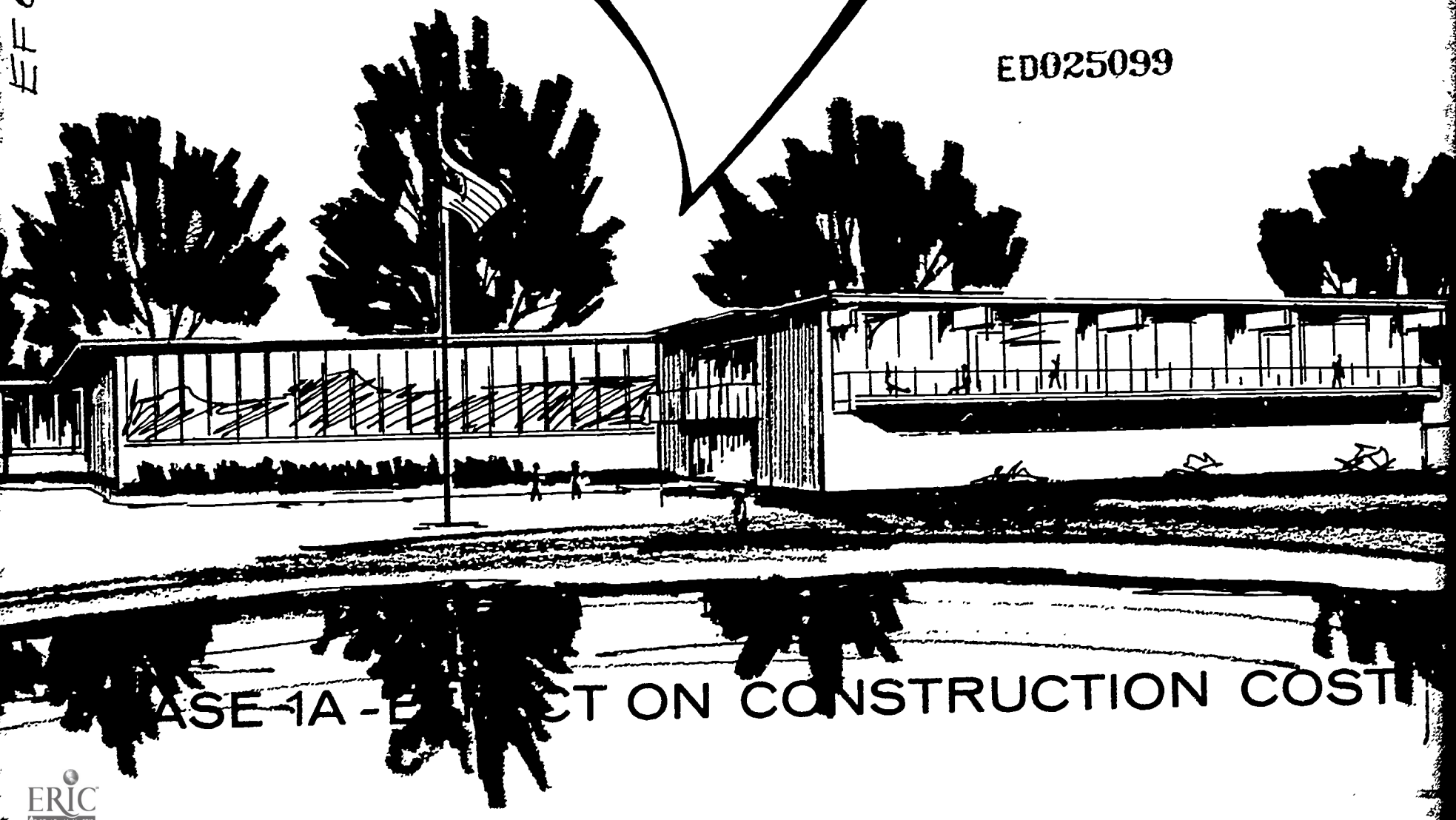
Phase 1A updates the original study of January 1965 and contains the sevenmost recent schools which in their development stages were bid for both gas and electric heating systems. In all cases the bids were for first cost, not for ultimate operating expense. Although the differences were relatively minor, six out of the seven gas bids were lower than the respective electrical bids. Each school is described by size, number of rooms, and number of students. Amounts bid for general work, heating, plumbing and electrical are given along with a description of construction materials and systems for each of the two heating designs. (NI)

SCHOOL HEATING

GAS VS. ELECTRIC

NORTHERN ILLINOIS GAS

Service around the clock



ASE 1A - E CT ON CONSTRUCTION COST

Forward

This book, Phase 1A, updates the original "School Heating - Gas vs. Electric" study by Frank R. Valvoda dated January, 1965.

Phase 1A contains the seven most recent schools which - in their development stages - were bid for both gas and electric systems. In all cases the bids were simultaneous. The purpose of the bidding, of course, was to determine which system would require the lowest first cost. Although the difference was a relatively minor one - and not statistically significant, as Valvoda points out - six of the seven gas first cost bids were actually lower.

We emphasize that these are first cost figures only. Operating costs, traditionally, are significantly lower with natural gas.

Frank R. Valvoda and Associates were selected to make this study for the following reasons:

1. They do not design heating or cooling systems - their practice is limited to electric engineering (with emphasis on lighting) - in essence they function as a consultant's consultant.
2. Their investigative/reportorial work with the magazine Actual Specifying Engineer (for which they are Engineering Consultants) puts them in a unique position to obtain facts from many sources.
3. They have prepared many technical reports of this kind in the past.

We are pleased to present to you this copy of Mr. Valvoda's report. Additional copies are available upon request.

M. S. DelCamp

SCHOOL HEATING

GAS VS. ELECTRIC

PHASE IA - EFFECT ON CONSTRUCTION COSTS

(UPDATING PHASE I REPORT DATED January, 1965)

By:

Frank R. Valvoda, P.E.

FRANK R. VALVODA & ASSOCIATES
256 Lake Street
Oak Park, Illinois 60302

Submitted to:

NORTHERN ILLINOIS GAS COMPANY
P.O. Box 190, Aurora, Illinois 60507

May, 1968

School Heating -- Gas vs. Electric
Phases I & IA -- Effect on Construction Costs

SUMMARY OF COSTS

Schools Bid Out to Both
Gas and Electric
Heating Designs

		Phase I	Phase IA	Both Phases
Number of Schools Studied				
Elementary		5	4	9
Junior High		2	1	3
High		1	2	3
				15
Design Having Lower First Cost				
Gas Design	No. of Schools	3	6	9
Electric Design	No. of Schools	5	1	6
				15
Design Selected for Construction				
Gas Design	No. of Schools	8*	5	13
Electric Design	No. of Schools	0	2	2
				15
Average Cost by Which Gas Designs were Lower in Cost than Electric Designs (Elementary schools)				
Cost per Square Foot		0.1%	1.7%	0.9%
Cost per Classroom		0.2%	1.7%	0.9%
Cost per Student		0.2%	1.7%	0.9%

*Design includes Heating & Air-Conditioning instead of Heating only, because separate bids were not taken for Air-Conditioning.

See Text of Report for details.

TABLE OF CONTENTS

1. PURPOSE OF STUDY

1.1 This report (Phase 1A) is an addendum to our report (Phase I) of January, 1965, updating all information and conclusions since the cut-off date of that report on May 15, 1964.

It is a continuation of that study and its purposes are identical and may be restated:

> "The purposes of this study....are to determine:
>
> "Is there a first-cost difference in schools which are heated electrically or by gas wet-heat?
>
> "When such first-cost information is available to authorities responsible for committing construction funds, which system of heating is chosen?"

1.2 The Phase I report introduces the study in the following way: "With the increasing emphasis on the most economical installation and operating costs, the possibility of using electric heat has presented itself as perhaps one way to reduce the overall costs of schools to the taxpayers.

"Many claims have been made concerning the advantages of electric heat over the conventional methods: lower first cost, lower operating energy cost, less maintenance, cleaner, quieter, smaller space requirements.

"Proponents of electric heat (utility companies, manufacturers, and others) have prepared typical estimates for installation and operating costs and have evaluated the subjective factors of cleanliness and quietness: all proving the advantages of electric heat.

"In rebuttal, proponents of gas-fired heat have prepared similar cost and subjective factor studies showing that gas-heat is the best from all viewpoints.

"Estimates of first- or construction-cost are always made by the architect of record on a school project when the budget is established -- many times setting the amount of money which must be realized through tax-supported bond issues.

"For these estimates the architect draws on his experience, his engineer's experience, and estimates of proponents (generally the utility companies) of the energy sources under consideration.

"These first-cost estimates plus similar operating-cost estimates and a study of all other factors are evaluated and form the basis of recommendations to the school authorities.

"Some school authorities, naturally desirous of obtaining the best and least costly heating systems for their schools, have requested their architect to design heating systems two ways: gas wet-heat and electric, receiving proposals from contractors for both systems. Because this almost doubles the work of the architect and of his mechanical and electrical engineers, the architect is quite understandably reluctant to prepare the two designs without extra compensation: sometimes a bone of contention between school board and architect.

"All concerned with the project, therefore, are vitally interested that the most accurate information be used as a basis for estimating and design; and that it be organized and presented according to the highest professional standards."

1.3 Continuing from the first report: "The Northern Illinois Gas Company, concerned with maintaining its high professional standing with architects and engineers and desiring to insure that its recommendations to architects and engineers have the firmest possible basis in demonstrable fact, requested the author to conduct for it a study of first- or construction-costs of schools within its operating area.

"The time for the study was propitious, there having been (up to the cut-off date established for the study) eight schools for which two equal heating systems were designed and two proposals taken -- a clear opportunity to establish whether there is indeed a first-cost difference in schools heated by gas wet-heat or electrically.

"In addition, there had been nine more schools designed for electric-only heating (no gas wet-heat design having been bid on) -- a potential control group providing a means of checking the two design schools for equality of the designs."

The data of this "control group" showed that designing a building with <u>both</u> Electric and Gas Designs did not bring about extra costs over those incurred with Electric Design only).

In this report seven additional schools were studied, using the methods of the first report -- seven schools where bids were accepted for both electric and gas designs.

1.4 The first study and this updating study comprise the first phase of a proposed long-range study <u>in depth</u> of both installation and operating costs of natural gas versus electric heating and cooling for a wide range of building types.

As with the first study, this report will be made generally available to all interested parties in order that the results and conclusions may be of value to architects, engineers, school authorities, and the public in general.

2. CONCLUSIONS

2.1 The conclusions of the first report were: "Based on all eight schools in the territory of the Northern Illinois Gas Company for which proposals were received for both designs -- designs described by the architects for the schools as being equal --

> "There is no significant first cost difference between schools heated electrically and by gas wet-heat, and
>
> "with such information available, authorities responsible for committing construction funds chose to heat their schools by gas wet-heat rather than electrically."

2.2 This study confirmed with minor differences, the conclusion of the Phase I report. For all fifteen schools studied to date:

> Statistically speaking, there is no significant first-cost difference between schools heated electrically and by gas wet-heat (for the elementary schools: gas wet-heat was lower in first cost by 0.2% for the first five schools and by 1.7% for the more recent four schools, for an overall average of 0.9%), and
>
> with such information available, authorities responsible for committing construction funds chose to heat their schools by gas wet-heat rather than electrically (13 of the 15 schools).

3. METHOD

3.1 Source of Data. Sole source of information on each school has been the architect of record for the school or his engineer.

3.2 Arrangement of Data. Information received on each school has been compiled into a Case History for that school. All pertinent data necessary to make comparisons appears in the Case History. Seven schools are included.

3.3 Interpretation of Data. The author has established for each school, based on data submitted by the architect, two independent measures for comparison purposes: "Cost per square foot" and "Cost per classroom" (the latter being related to a third measure: "Cost per student"). Further comparisons have been made regarding equipment and facilities. Summaries and conclusions are based on these interpretations.

3.4 Method followed has been identical with that of Phase I.

4. DATA ACCUMULATION

4.1 Basis of Data Accumulation. All data on the schools studied was furnished and verified by the architect of record for the project, except in those cases where the architect's engineer provided all or a portion of the information at the architect's request. No data furnished has been amended or edited except at the request of the architect or with his permission. Tabulations of cost comparisons and summaries have been prepared by the author using only data furnished by the architect or engineer for the schools studied.

4.2 Procedures Followed. In order that the data presented be as accurate as possible, an extremely detailed procedure was followed -- checking and re-checking at each step as information was received. The following steps were encompassed in all but a few cases where some of the first steps were omitted or accommodated out of order in the interests of saving time:

4.2.1 A list of schools was prepared by the Northern Illinois Gas Company giving name, location, and architect of record for every school in the territory of NI-Gas Co. for which plans were prepared for heating by both gas and electric designs since the cut-off date for the first report of May 15, 1964.

The accuracy of the list furnished was checked with the electric utility companies having jurisdiction in the same areas (Public Service Company, Commonwealth Edison Company, Illinois Power Company, Central Illinois Electric and Gas Company).

4.2.2 A letter was sent the architect of each school describing the purposes of the study and requesting an interview.

4.2.3 A telephone call was made to each architect to answer any questions and to establish a date and time for the interview.

4.2.4 During the interview, lasting twenty minutes to an hour, a copy of the Questionnaire was filled out by the author as the architect answered the questions put to him. In certain instances when the architect was too busy to take the necessary time due to commitments arising after the appointment was set, the author obtained the information himself from drawings and specifications made available to him by the Architect. A copy of the Questionnaire appears in the Appendix.

4.2.5 The author then transcribed the Questionnaire and sent two copies to the architect for verification of all information presented. One copy of the Questionnaire, corrected as required, together with one copy

of a Release Form, giving the author permission to use the data as he saw fit, was returned. A copy of the Release Form appears in the Appendix.

4.2.6 The author prepared the Case History for each school, utilizing data from the corrected Questionnaire. When necessary to complete or verify additional points, the Case History was sent to the architect for his comments. The Case Histories form the bulk of the report.

4.2.7 The summaries and cost comparisons were prepared by the author and conclusions were drawn therefrom.

4.3 No architect nor engineer employed by him received compensation for time and effort devoted to gathering and preparing the data. Each was, however, promised for his own use copies of the author's final report as presented to Northern Illinois Gas Company -- even if NI-Gas chose for its own reasons not to publish the full report.

4.4 No further attempts have been made to evaluate the statistical significance of the data, as the author recognizes the small number of cases studied. On the other hand, the report covers all cases as noted through July 1, 1967, and stands on that firm ground.

4.5 Data Accumulation has been identical with that of Phase I.

5. CASE HISTORIES

5.1 In this section of the report is presented the Case History for each school studied, containing information furnished and verified by the architect or his representative (as noted).

5.2 The following Case Histories appear, where each school had prepared for it both electric and gas-wet heat designs:

	School Name	Architect
#31	Virginia Lake Elementary Palatine, Illinois	Del Bianco Associates Chicago, Illinois
#32	Sycamore High School Sycamore, Illinois	Gilbert A. Johnson, Kile, Seehausen & Associates Rockford, Illinois
#33	Long Beach (Boulder Hill) Oswego, Illinois	Robert F. Mall Aurora, Illinois
#34	Spaulding Elementary Midlothian, Illinois	Jacobs & Evans South Holland, Illinois

#35	Helen Keller Junior H. S. Schaumburg, Illinois	R. O. Mitter* Villa Park, Illinois
#36	Tinley Heights Elementary Cook County, Illinois	Alexander, Borkon, Westphal & DeYoung Joliet, Illinois
#37	Glenbard North High School Glen Ellyn, Illinois	Nicol and Nicol Inc. Chicago, Illinois

* Consulting Engineer

B1A CASE HISTORY -- SCHOOLS
Comparison of Gas and Electric Heating Systems -- First Cost Only

School: Virginia Lake Elementary
Palatine, Illinois

District: 15
Superintendent: Mr. Pat Castor

Description of Building (as built or to be built):

Size: 43542 ft.^{2} - 1st Floor
4600 ft.^{2} - Basement

Classrooms: 25

Students: 720

Other Rooms:

Multi-purpose room, staff room, library, office, principal, toilets, storage, lunch room (basement), storage (basement), conference (two).

Completion Date: May, 1966

Architect: Del Bianco Associates
Chicago, Illinois

Engineer: Mech. & Elect. Kralovec & Best
Chicago, Illinois

Engineer: Struct. J.P. Donovan & Associates
Chicago, Illinois

Remarks:
Electric design was accepted, but with small contract changes from as bid.

Two school projects were bid at the same time to take advantage of possible construction cost savings. (Second school was an all-gas addition to existing building).

Information furnished (April 26, 1967) and verified by Mr. Gino Marsalli, Del Bianco Associates; and by Mr. Michael Best (July 6, 1967), Kralovec & Best.

Per Mr. Best: "After a comparison of equal first costs for comparable designs, selection of energy source must be made on the basis of energy cost per square foot per year and total maintenance costs per year. Either (or both) may be critical to the final choice."

31B DESIGN: ELECTRIC

Date Bids Received: May 3, 1965

Trade	Bid Amount		No. of Bids Taken
General Work	$422,179.	(incl. Site Work)	7
Heating	25,400.		9
Plumbing	42,785.		5
Electrical	112,965.		9
Totals	$603,329.		

Remarks:

Construction Materials:

Floor: 4" concrete slab; 2"x2' styrofoam perimeter insulation.

Walls: 4" face brick; 2" styrofoam; 4" block; (8" block in Multi-purpose). Curtain walls (1/3 glass, 2/3 panel): 1" urethane foam; glassweld.

Roof: Bar joists; 1" formboard; 2-1/2" gypsum; 1" styrofoam; 3-ply tar & gravel.

Ceiling: 5/8" acoustical tile; (exposed precast concrete in Multi-purpose room)

Glass: 1/2" insulated glass in curtain walls; (1/4" plate glass in small areas)

Description of Systems:

Service:	277/480-volt, 3Ø, 4w, s/n pad-mounted transformer at grade. Underground primary. 600 A. & 350 A circuit breakers. Lighting, etc., at 120/208-volts through ratio transformers.
Lighting:	Fluorescent. Classrooms: 50 fc. (per school code)
Water heating:	Gas. Electric (booster) for toilets, etc.
Cooking:	None.
Incineration:	None.
Heating:	In general, electric unit ventilators for each classroom; with electric baseboard for small offices and multi-purpose room, supplemented with a separate ventilation system. Baseboard radiation is SCR-controlled. Night set-back control is used throughout.

1c

DESIGN: GAS

Date Bids Received: May 3, 1965

Trade	Bid Amount		No. of Bids Taken
General Work	$407,242.	(incl. Site Work)	7
Heating	105,400.		9
Plumbing	42,400.		5
Electrical	62,845.		9
Totals	$617,887.		

Remarks:

Construction Materials:

Floor: 4" concrete slab; 2" x 24" styrofoam perimeter insulation.

Walls: 4" face brick; 4" concrete block (8" block in Multi-purpose room). Curtain wall (1/3 glass): 1" insulated panelboard; 7/32" plate glass.

Roof: Bar joists; 1" formboard; 2-1/2" gypsum; 3-ply tar & gravel.

Ceiling: 5/8" acoustical tile (exposed precast concrete in Multi-purpose room).

Glass: 7/32" plate glass (1/4" plate glass in small areas).

Description of Systems:

Service: 120/208-volt, 3ø, 4w, s/n, pad-mounted transformer at grade. Underground primary. 800 A. circuit breaker, 60 A. emergency.

Lighting: Fluorescent. Classrooms: 50 fc. (per school code)

Water heating: Gas.

Cooking: None

Incineration: None.

Heating: In general, unit ventilators are provided for each classroom; with hot water baseboard for small offices and multi-purpose room, supplemented with a separate ventilation system. Boiler has 300 ft.^{2} of heating surface. Controls are pneumatic (alternate on electric would have been approved if submitted).

32A CASE HISTORY -- SCHOOLS
Comparison of Gas and Electric Heating Systems -- First Cost Only

School: Sycamore High School
Sycamore, Illinois

District: 427
Superintendent: Mr. Graydon Peterson

Description of Building (as built or to be built):

Size: 71,457 ft.^{2}

Classrooms: 8

Students: 300 (excluding gymnasium facilities)

Other Rooms:

Gymnasium, locker & shower rooms, shops, offices.

Completion Date: July 1, 1967

Architect: Gilbert A. Johnson, Kile, Seehausen & Associates
Rockford, Illinois

Engineer: Mech. & Elect.: Donald R. Johnson & Associates
Rockford, Illinois

Engineer:

Remarks:
Project is an addition to an existing electrically-heated school. No air-conditioning contemplated.

Gas was selected as the energy source; but all proposals were rejected for budgetary reasons, and the project was re-bid as a wet-heat project only.

Information furnished (May 1, 1967) and verified by Messrs. Kile & Merhar; of Gilbert A. Johnson, Kile, Seehausen & Associates.

32B DESIGN: ELECTRIC

Date Bids Received: July, 1965

Trade	Bid Amount		No. of Bids Taken
General Work	$ 867,000.	(incl. Site Work)	7
Ventilating	53,606.		5
Plumbing	50,607.		4
Electrical	119,963.	(genl. ltg. & power)	3
	+ 114,785.	(electric heating, incl. Controls)	
Totals	$1,205,961.		

Remarks:

Construction Materials:

Floor: 4" slab on grade, 2"x2'-0" rigid perimeter insulation.

Walls: 4" brick, 2-1/2" vermiculite, 8" block.

Roof: 3" poured gypsum, 1-1/2" urethane insulation, built-up roofing.

Ceiling: Acoustical tile (classrooms only).

Glass: Thermopane, some glass block.

Description of Systems:

Service: 277/480-volt, 3Ø, 4w, s/n -- Existing. Transformation to 120/208V for lighting. Existing 2500 A. ACB changed to 3000 A.

Lighting: Fluorescent. Classrooms: 50 fc; Mechanical drawing: 97 fc; Shops: 75 fc; Gymnasium: 36 fc (1500 ma lamps).

Water heating: Gas (Existing).

Cooking: None.

Incineration: None.

Heating: In general, system consists of an electrical distribution system employing resistance-type heaters in classroom unit ventilators, baseboard convectors, and auditorium-type unit ventilators. No air-conditioning. Heat loss: 2,696,000 Btuh.

32c DESIGN: GAS

Date Bids Received: July, 1965

Trade	Bid Amount		No. of Bids Taken
General Work	$ 869,645.	(incl. Site Work)	7
Heating	100,770.	(incl. Controls)	5
Ventilating	53,606.		5
Plumbing	52,560.		4
Electrical	119,963.		3
Totals	$1,196,544.		

Remarks:

Construction Materials:

Floor: 4" slab on grade, 2"x2'-0" rigid perimeter insulation.

Walls: 4" brick, 2-1/2" vermiculite, 8" block.

Roof: 3" poured gypsum, 1-1/2" rigid insulation, built-up roofing.

Ceiling: Acoustical tile (classrooms only).

Glass: 3/16" heavy sheet, some glass block.

Description of Systems:

Service: 277/480-volt, 3ø, 4w, s/n -- Existing. Transformation to 120/208V.

Lighting: Fluorescent. Classrooms: 50 fc; Mechanical drawing: 97 fc; Shops: 75 fc; Gymnasium: 36 fc (1500 ma. lamps).

Water heating: Gas (Existing).

Cooking: None.

Incineration: None.

Heating: In general, system consists of a gas-fired hot-water boiler serving through a two-pipe system classroom unit ventilators, fin-tube convectors, and auditorium-type unit ventilators. No air-conditioning. Heat loss: 2,871,000 Btuh.

3A CASE HISTORY -- SCHOOLS
Comparison of Gas and Electric Heating Systems -- First Cost Only

School: Long Beach (Boulder Hill) District: 308
Oswego, Illinois Superintendent: Mr. T. Lloyd Traughber

Description of Building (as built or to be built):

Size: 28,834 ft.^{2} Classrooms: 15 Students: 420

Other Rooms:

Library, multi-purpose, administrative suites, service area.

Completion Date: June 1, 1967

Architect: Robert F. Mall
Aurora, Illinois

Engineer: Mech. & Elect. Beling Engineering Consultants
Joliet, Illinois

Engineer:

Remarks:
Gas design was accepted.

Information furnished (April 27, 1967) and verified by Mr. Richard Tater, of Robert Mall's office; and by Mr. Kenneth Glascow (July 10, 1967) of Beling Engineering Consultants.

83B DESIGN: ELECTRIC

Date Bids Received: July 28, 1966

Trade	Bid Amount		No. of Bids Taken
General Work	$334,128.		5
Ventilating	11,250.		2
Plumbing	33,957.		5
Electrical	105,880.	(incl. in Controls)	3
Totals	$485,215.		

Remarks: Boiler Room of Gas Design is a Classroom in this design. No stack in this design.

Construction Materials:

Floor: 4" slab on grade; 1" perimeter insulation.

Walls: 6" block; 2" cavity insulation (poured vermiculite); 4" brick.

Roof: 1/2" formboard; 2-1/2" gypsum; 2" rigid insulation; built-up roofing.

Ceiling: Acoustical tile.

Glass: 1/4" plate.

Description of Systems:

Service: 120/208-volt, 3ø, 4w, s/n; underground from pad-mounted transformer at grade. Underground primary; 1000 A, 1000 A, 500 A circuit breakers, 30 A Fused switch emergency.

Lighting: Fluorescent: 50 fc. (Filament accent lighting).

Water heating: Gas (for kitchen) and Electric (for toilets).

Cooking: Gas.

Incineration: Gas.

Heating: In general, classrooms are heated by classroom unit ventilators (Chromalox), with electric baseboard for miscellaneous areas.
Controls are electric, with time clock for night set-back.

3c DESIGN: GAS

Date Bids Received: July 28, 1966

Trade	Bid Amount		No. of Bids Taken
General Work	$328,128.	(incl. in Site Work)	5
Heating	50,677.	(incl. in Controls)	5
Ventilating	11,250.		2
Plumbing	33,957.	(incl. Sewers)	5
Electrical	38,275.		3
Totals	$462,287.		

Remarks:

Construction Materials:

Floor: 4" slab on grade; 1" perimeter insulation.

Walls: 4" brick; 8" block.

Roof: 1" formboard; 2" gypsum; built-up roofing.

Ceiling: Acoustical tile.

Glass: 1/4" plate.

Description of Systems:

Service: 120/208-volt, 3Ø, 4w, s/n; underground from pad-mounted transformer at grade. Underground primary. 500A. circuit breaker, 30A. Emergency.

Lighting: Fluorescent: 50 fc. (Filament accent lighting).

Water heating: Gas (for kitchen) and Electric (for toilets).

Cooking: Gas.

Incineration: Gas.

Heating: In general, classrooms are heated by classroom unit ventilators (Herman Nelson), with baseboard radiation for miscellaneous areas.
Boiler room is sized for future hot water boiler.
Controls are pneumatic or electric, with time clock for night set-back.

34A CASE HISTORY -- SCHOOLS
Comparison of Gas and Electric Heating Systems -- First Cost Only

School: Spaulding Elementary
Midlothian, Illinois

District: 143
Superintendent: Mr. John P. Hayes

Description of Building (as built or to be built):

Size: 32,850 ft.^{2}

Classrooms: 20

Students: 700

Other Rooms:

Gymnasium with stage, kitchen, administration, library, toilets.

Completion Date: August 1, 1967

Architect: Jacobs & Evans
South Holland, Illinois

Engineer: Mech. & Elect.: K-C & M Engineers & Associates, Inc.
Crestwood, Illinois

Engineer:

Remarks:
Electric design was accepted.

Information furnished (April 27, 1967) and verified by Mr. Harold Jacobs, of Jacobs & Evans.

34 5 DESIGN: ELECTRIC

Date Bids Received:

Trade	Bid Amount		No. of Bids Taken
General Work	$372,684.	Deductive alternates accepted in reducing building size from 20 to 16 classrooms: Genl: $45,443.	6
Heating	110,000.	Htg,	6
Plumbing	31,494.	Elect: 6,880. Plbg: 240.	5
		Deductive alternate for change to single-glaze glass: Genl: $ 1,680.	Additive alternate to change fan-coil units to accept future air-conditioning: Htg, Elect: Schemenauer units: $7,500. Nesbitt units: $4,800.
Totals	$514,178.		

Remarks:
Boiler Room of Gas Design is a Storage Room in this design.

Construction Materials:

Floor: 4" slab on grade; 2"x24" perimeter insulation.

Walls: 4" face brick; 2" styrofoam; 4" block.

Roof: 6" metal deck; vapor barrier; 4" rigid insulation; 4-ply T & G built-up roofing; (Fibreglass batt inside metal deck at outside walls).

Ceiling: Exposed roof deck.

Glass: Curtain wall: 16 ga. porc. enamel face; 1-1/2" polyurethane core; 20 ga. galvanized back; 1/2" insulating glass.

Description of Systems:

Service: 277/480-volt, 3Ø, 4w, s/n; underground from pad-mounted transformer; 1000 A. circuit breaker (600 A. trip); 150 A. circuit breaker for water heating; 225 A. circuit breaker. 120/208-volt transformation.

Lighting: Fluorescent, 70 fc.

Water heating: Electric (several small units).

Cooking: Electric.

Incineration: None.

Heating: In general, system includes classroom unit ventilators in classrooms, air-handling unit for heating and ventilating in gymnasium/auditorium, cabinet unit heaters in corridors, and baseboard radiation or unit heaters in miscellaneous areas.
Equipment: Schemenaur.
Air-conditioning (future) is electric-drive to serve classrooms only. Roof-top unit is in initial work for administrative area.
Controls are pneumatic.

34A CASE HISTORY -- SCHOOLS
Comparison of Gas and Electric Heating Systems -- First Cost Only

School: Spaulding Elementary
Midlothian, Illinois

District: 143
Superintendent: Mr. John P. Hayes

Description of Building (as built or to be built):

Size: 32,850 ft.^{2} Classrooms: 20 Students: 700

Other Rooms:

Gymnasium with stage, kitchen, administration, library, toilets.

Completion Date: August 1, 1967

Architect: Jacobs & Evans
South Holland, Illinois

Engineer: Mech. & Elect.: K-C & M Engineers & Associates, Inc.
Crestwood, Illinois

Engineer:

Remarks:
Electric design was accepted.

Information furnished (April 27, 1967) and verified by Mr. Harold Jacobs, of Jacobs & Evans.

34c DESIGN: GAS

Date Bids Received: April 15, 1966

Trade	Bid Amount		No. of Bids Taken
General Work	$354,684.	Deductive alternates accepted in reducing building size from 20 to 16 classrooms: Genl: $41,693.	6
Heating	73,200.	Htg: 5,178.	6
Plumbing	31,494.	Plbg: 240.	5
Electrical	51,199.	Elect: 2,120.	6
Totals	$510,577.	Additive alternate (Not accepted) to provide for future air-conditioning: Elect: $750.	

Remarks:

Construction Materials:

Floor: 4" slab on grade; 2"x24" perimeter insulation.

Walls: 4" face brick; 4" block.

Roof: 6" metal deck; vapor barrier; 1-1/2" rigid insulation; 4-ply T & G built-up roofing. (Fibreglass batt inside metal deck at outside walls).

Ceiling: Exposed roof deck.

Glass: Curtain wall: 16 ga. porc. enamel face; 1-1/2" polyurethane core, 20 ga. galv. back; 1/8" DSA glass.

Description of Systems:

Service: 120/208-volt, 3Ø, 4w, s/n, underground from pad-mounted transformer; 800 Ampere w/600 Ampere fuses.

Lighting: Fluorescent, 70 fc.

Water heating: Gas.

Cooking: Electric.

Incineration: None.

Heating: In general, system includes classroom unit ventilators in classrooms, air-handling unit for heating and ventilating in gymnasium/auditorium, fan-coil units in corridors, and finned radiation in miscellaneous areas. Equipment: Schemenaur. Boilers (two): Weil-McLain Model 1094, each at 8450 net EDR-IBR.
Air-conditioning (future) is electric-drive to serve classrooms only. Roof-top unit is in initial work for administrative area.
Controls are pneumatic.

5A CASE HISTORY -- SCHOOLS
Comparison of Gas and Electric Heating Systems -- First Cost Only

School: Helen Keller Junior High School District: Schaumburg #54
Superintendent:
Bode Rd., Schaumburg, Ill.
Description of Building (as built or to be built):

Size: (incl. alternates): 64,849 ft.^{2} Classrooms: 20 Students: 900 now, 1200 future.

Other Rooms:

30 Offices, incl. storage rooms
1 Special Education Group Teaching room
1 Chorus room
1 Band room
2 Laboratories
2 Art rooms
2 Gymnasiums
2 Locker rooms, plus shower rooms
1 Cafetorium

Completion Date: September, 1967 (est.)

Architect: Frazier, Raftery, Orr & Fairbank
Geneva, Illinois

Engineer: Mech. & Elect. R. O. Mitter
Villa Park, Illinois

Engineer: Struct. William Schmidt & Associates
Chicago, Illinois

Remarks:
Gas Design was accepted.

Information furnished (October 20, 1966) and verified by Richard O. Mitter.

35B DESIGN: ELECTRIC

Date Bids Received:

Trade	Bid Amount			No. of Bids Taken
General Work	$469,707.	$71,362.	Gym. $8,793.	Canopy
Heating)) = Ventilating)	176,000.	9,000.		
Controls	29,280.	1,285.		
Plumbing	85,793.	1,310.	673.	
Electrical	124,990.	5,847.	1,235.	
Miscellaneous	46,106.	Partitions		
Totals	$931,876. +	$88,804. +	$10,701. =	$1,031,381.

Remarks: Not included in above: $58,389. Fixed Equipment
$63,654. Architect's Fee (based on Gas Design).

Construction Materials: (Same as Gas Design)

Floor: 6" porous fill, vapor barrier, 5" slab, resilient flooring (some carpeting).

Walls: Facebrick, 1/2" parging, 1" rigid insulation, 8" block.

Roof: Built-up roofing, 1-3/4" rigid insulation, 1-1/2" metal deck.

Ceiling: Acoustical tile. 9' height in general, some 11' and 12' heights, 15' in Gymnasium.

Glass: Dual glazed with interior venetian blinds between two glazed panels.

Other: Building is on a 5-foot module. General classrooms and offices utilize movable partitions.

Description of Systems:

Service: 277/480-volt, 3Ø, 4w, s/n. Service switches: 2000 A. for electric heating; 800 A. for heating, ventilating, air-conditioning; 600 A. for lighting; 120/208-V transformation.

Lighting: Fluorescent. Classrooms: 70 fc; Art rooms: 100 fc; Cafetorium: 40 fc; Gymnasium: 50 fc. (All at 277-V with remote, low-voltage switching.)

Water heating: Electric.

Cooking: None.

Incineration: Gas.

Heating, Air-Conditioning: In general, heating and ventilating for all areas, together with year-round air-conditioning systems for classroom areas only. Classroom and Administration areas are provided with central plant medium pressure distribution systems utilizing zone electric reheat boxes with individual room control and constant air circulation. Cooling is by electric-drive compressor/condenser units.
Main gymnasium, 2nd gymnasium, locker-shower, and cafetorium areas are provided with separate heating and ventilating systems.

85c DESIGN: GAS

Date Bids Received:

Trade	Bid Amount			No. of Bids Taken
General Work	$469,707.	$71,362.	Gym. $8,793.	Canopy
Heating) = Ventilating)	191,200.	9,000.		
Controls	16,473.	895.		
Plumbing	87,430.	1,310.	673.	
Electrical	92,484.	5,847.	1,235.	
Miscellaneous	46,106.	Partitions		
Totals	$903,400.	+ $88,414.	+ $10,701.	= $1,002,515.

Remarks: Not included in above: $58,389. Fixed Equipment.
$63,654. Architect's Fee.

Construction Materials: (Same as Electric Design)

Floor: 6" porous fill, vapor barrier, 5" slab, resilient flooring (some carpeting).

Walls: Facebrick, 1/2" parging, 1" rigid insulation, 8" block.

Roof: Built-up roofing, 1-3/4" rigid insulation, 1-1/2" metal deck.

Ceiling: Acoustical tile. 9' height in general, some 11' and 12' heights, 15' in Gymnasium.

Glass: Dual glazed with interior venetian blinds between two glazed panels.

Other: Building is on a 5-foot module. General classrooms and offices utilize movable partitions.

Description of Systems:

Service: 120/208-volt, 3Ø, 4w, s/n; underground from pad-mounted transformer. 1200 A. service switch. Fused switches.

Lighting: Fluorescent. Classrooms: 70 fc; Art rooms: 100 fc; Cafetorium: 40 fc; Gymnasium: 50 fc.

Water heating: Gas.

Cooking: None.

Incineration: Gas.

Heating, Air-Conditioning: In general, heating and ventilating for all areas, together with year-round air-conditioning systems for classroom areas only. Classroom and Administration areas are provided with central plant medium pressure duct distribution systems utilizing zone mixing boxes with individual room control and constant air circulation.
Cooling is by two (1 @ 85 tons, 1 @ 110 tons) gas-engine driven refrigerating-condensing units. Main gymnasium, 2nd gymnasium, and cafetorium areas are provided with separate heating and ventilating systems and locker-shower, miscellaneous storage, and receiving rooms are provided with heating only using variable volume zone control.

36A CASE HISTORY -- SCHOOLS
Comparison of Gas and Electric Heating Systems -- First Cost Only

School: Tinley Heights Elementary
Cook County, Illinois
District: 140
Superintendent: Mr. John A. Bannes

Description of Building (as built or to be built):

Size: 24,480 ft.^{2} Classrooms: 14 Students: 700

Other Rooms:

Multi-purpose, administrative, conference, audio-visual, speech, storage.

Completion Date:

Architect: & Engineer: Alexander, Borkon, Westphal, & DeYoung
Joliet, Illinois

Engineer: Elect.: K-C & M Engineers & Associates, Inc.
Crestwood, Illinois

Engineer:

Remarks:
Gas design was accepted.

Future addition of same size will be built to the east.

Information furnished (April 27, 1967) and verified by Mr. Dillard B. Alexander, of Alexander, Borkon, Westphal & DeYoung.

6B DESIGN: ELECTRIC

Date Bids Received: November 9, 1966

Trade	Bid Amount		No. of Bids Taken
General Work	$210,104.		
Heating	44,118.	(incl. electric heating)	
Plumbing	24,700.		
Electrical	28,978.	(Genl. power & Lighting)	
Totals	$307,900.		4

Remarks:
All trades were under General Work bid. Low bidder on Electric Design was not low bidder on Gas Design.

Construction Materials:
(Same as Gas Design)

Floor: 4" slab on grade; 2"x2'-0" rigid perimeter insulation.

Walls: 4" face brick; 2" rigid insulation; 8" concrete block; (liquid tile wainscot part way up).

Roof: Laminated beams; fibre deck and bulb tees; 2" rigid insulation; built-up roofing.

Ceiling: Acoustical tile in kitchen, corridors, mechanical equipment, and storage; exposed deck otherwise.

Glass: 1/4" plate glass.

Description of Systems:

Service: 120/208-volt, 3Ø, 4w, s/n, underground from pad-mounted transformer; underground primary. Circuit breakers: 1200 A, 150 A, 400 A, 50 A.

Lighting: Fluorescent, 70 fc.

Water heating: Electric.

Cooking: Electric (PTA-type kitchen).

Incineration: None.

Heating: Heating system utilizes Herman Nelson electric classroom unit ventilators with electric baseboard radiation.
Controls are specified for either pneumatic or electric. Day-night controls for classroom unit ventilators are operated on a central time clock.
No provision is made for future air-conditioning.

36c DESIGN: GAS

Date Bids Received: November 9, 1966

Trade	Bid Amount	No. of Bids Taken
General Work	$198,261.	
Heating	42,463.	
Plumbing	24,275.	
Electrical	34,500.	
Totals	$299,499.	4

Remarks:
All trades were under General Work bid. Low bidder on Gas Design was not low bidder on Electrical Design.

Construction Materials:
(Same as Electrical Design)

Floor: 4" slab on grade; 2"x2'-0" rigid perimeter insulation.

Walls: 4" face brick; 2" rigid insulation; 8" concrete block; (liquid tile wainscot part way up).

Roof: Laminated beams; fibre deck with bulb tees; 2" rigid insulation; built-up roofing.

Ceiling: Acoustical tile in kitchen, corridors, mechanical equipment, and storage; exposed deck otherwise.

Glass: 1/4" plate glass.

Description of Systems:

Service: 120/208-volt, 3ø, 4w, s/n; underground from pad-mounted transformer; underground primary. 400 A. Fused Switch and 50 A. circuit breaker (emergency).

Lighting: Fluorescent, 70 fc.

Water heating: Gas.

Cooking: Electric (PTA-type kitchen).

Incineration: Gas (Future. Not in original design).

Heating: Heating system is two-pipe hot water, utilizing Nesbitt Classroom unit ventilators in classrooms and corridors, baseboard radiation in classrooms, and unit heaters in some corridors. Boiler is Weil-McLain 1485 MBH. Controls are pneumatic. Day-night controls for classroom unit ventilators are operated on a central time clock. No provision is made for future air-conditioning.

7A CASE HISTORY -- SCHOOLS
Comparison of Gas and Electric Heating Systems -- First Cost Only

School: Glenbard North High School District: Township H. S. #87
Superintendent: Dr. D. W. Stoakes

Description of Building (as built or to be built):

Size: 304,000 ft.^{2} Classrooms: 65 (incl. shops) Students: 2000 + core (facilities for 3000 total)

Other Rooms:
Library, Laboratories, Work Rooms, Offices, Storage, Locker Rooms, Shower Rooms, Gymnasium, Field House, Cafeteria, Kitchen, Choral Rooms, Band Rooms, Auditorium, Little Theater, Shops, Faculty Dining.

Completion Date: February 1, 1968

Architect: Nicol and Nicol Inc.
Chicago, Illinois

Engineer: Mech. A. & T. Engineering
Chicago, Illinois

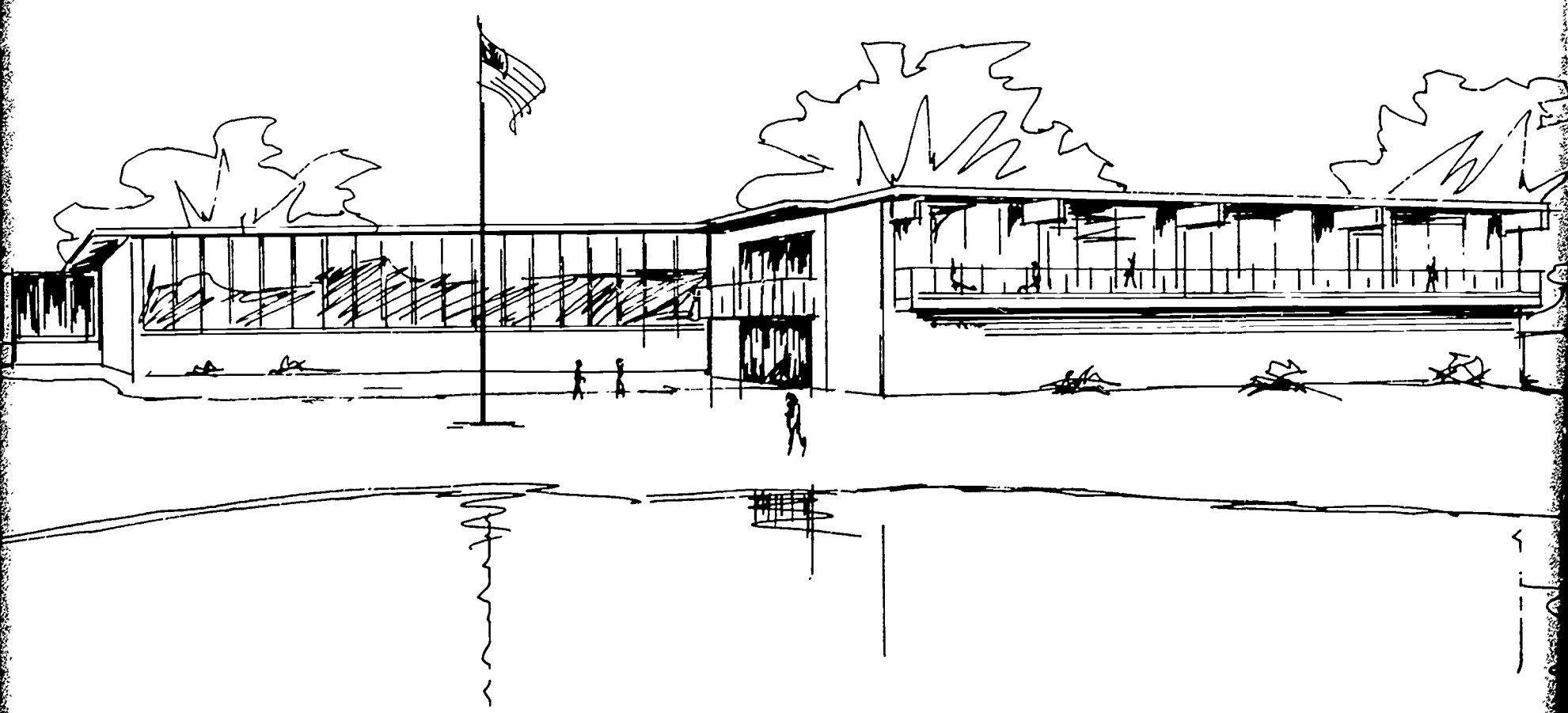
Engineer: Elect. Engineering Associates
Villa Park, Illinois

Engineer: Struct. Eugene A. Dubin
Chicago, Illinois

Remarks:
Gas Design was accepted.

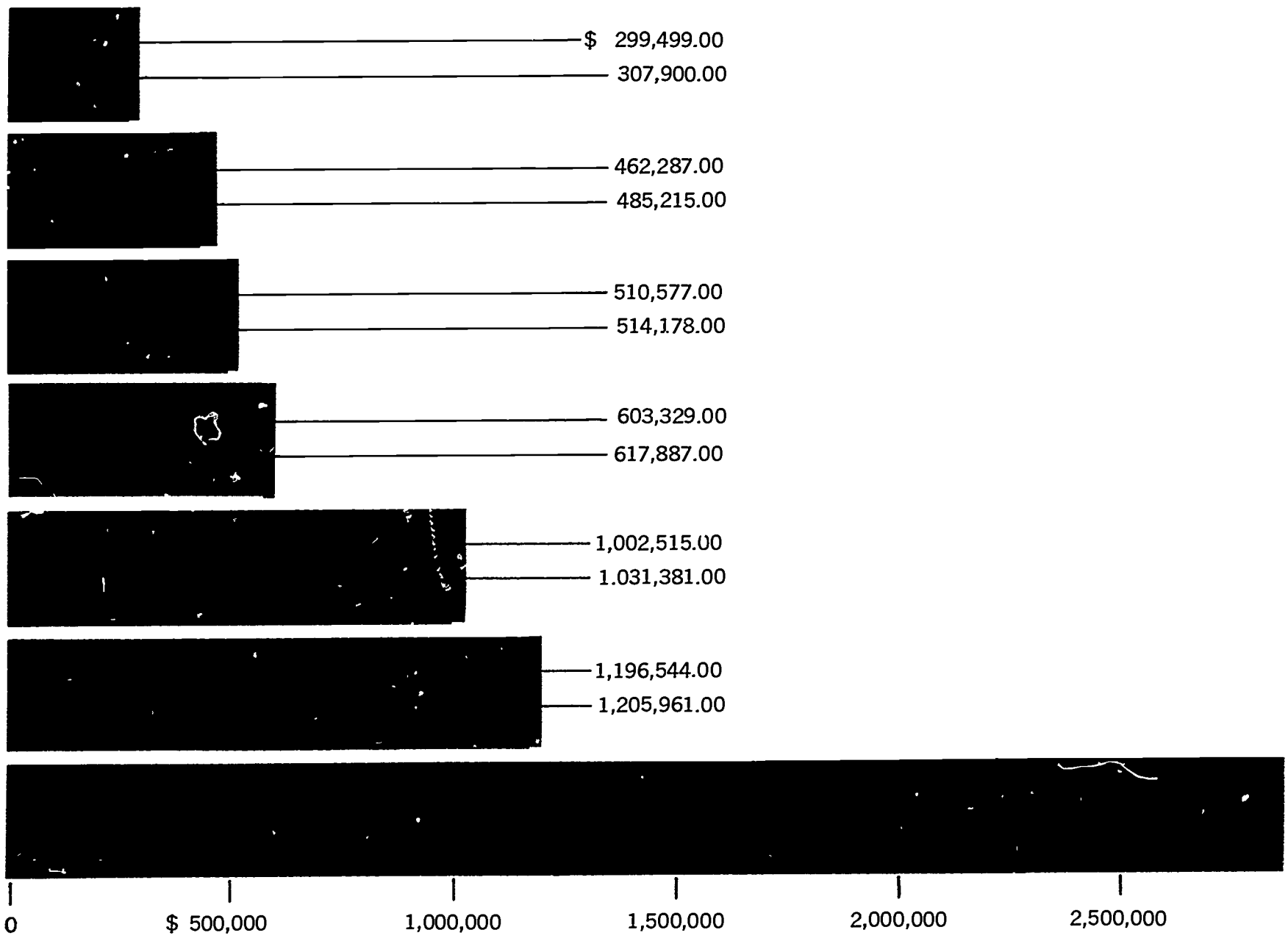
Information furnished (April 24, 1967) and verified by Mr. Robert Nicol, of Nicol and Nicol Inc.

Why simultaneous dual bids?



THE GRAPH SHOWS THE RELATIONSHIP OF TOTAL CONSTRUCTION COSTS BETWEEN GAS AND ELECTRIC SCHOOLS

Blue: Gas First Cost
Gray: Electric First Cost



gas heated schools traditionally

WHY SIMULTANEOUS DUAL BIDS?

To be meaningful, competitive school construction bids should be made under circumstances as nearly identical as possible.

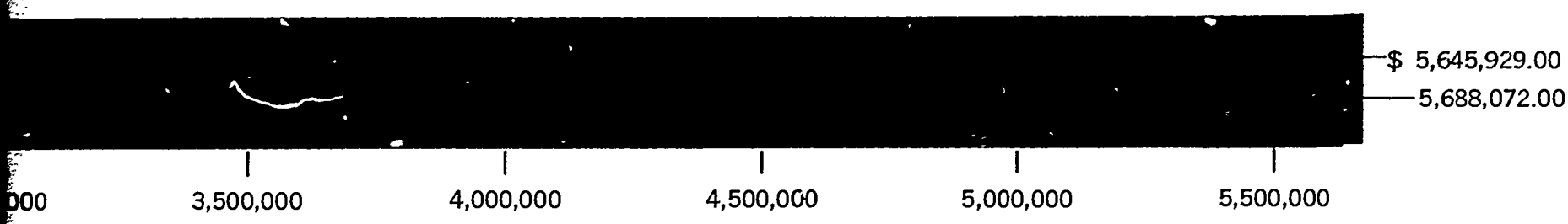
A number of factors can distort a second bid made at a different time. Minor modifications in the plans, of course. And time, itself.

For this reason, Valvoda included in his study only schools which were designed for both gas and electric heat and were dual bid, at the same time, from the same plans.

Bidding results of seven dual-bid schools are presented on this page. These are the *most recent* dual-bid schools in the Northern Illinois Gas Company service area.

An interesting point: Although the difference was not statistically significant, in *six* of the seven schools the *gas* equipment first cost was less than the electric equipment first cost .

And, of course, first-cost figures do not take into account the traditional *operating* economies of natural gas.



re also lower in Operating Costs

NORTHERN ILLINOIS GAS COMPANY

Service around the clock

B7 B DESIGN: ELECTRIC

Date Bids Received:

Trade	Bid Amount
General Work	$3,289,536.
Heating	468,000.
Ventilating	610.000.
Plumbing	492,200.
Electrical	828,336.
Totals:	$5,688,072.

No. of Bids Taken

7 (General Work bids included all subcontractors).

Remarks:
Electric Design was Base Bid, Gas Design was Alternate #1.
Site Work (est.) -- $590,000 -- To be done in Summer, 1967 and 1968.
Construction Materials: (Same as Gas Design)

Floor: 5" concrete on grade; 1-1/2"x2'-0" perimeter insulation; in general resilient tile, but some carpeting, some ceramic tile.
Walls: 4" face brick, 1-5/8" air space, 1-1/2" rigid insulation, 6" concrete block. Field House & Gym w/insulated metal wall panels.
Roof: 1" formboard, 2" gypsum board, 2-1/2" layers of rigid insulation, with built-up roofing.
Ceiling: Suspended acoustical tile.

Glass: Glare reducing glass.
Other: Stack with Gas Design. Boiler Room floor dropped and expanded to accept boilers. No other changes in construction.

Description of Systems:

Service: 480/277-volt, 3ø, 4w, s/n; from transformer vault outside building; 600A. and 1200A. fused switches; Fluorescent and mercury-vapor lighting at 277V; 120/208-volt transformation
Lighting: Fluorescent, 70 fc.
Water heating: Electric.
Cooking: Electric and Gas.
Incineration: Gas (Future; Separate stack).
Heating & Air-Conditioning: In general, large air supply units with heating and cooling coils and serving distinct areas provide air distribution. Reheat boxes to properly temper the air for each room are located above the corridors. Other areas utilize force-flow convectors, unit heaters, cabinet convectors, and baseboard radiation. For very cold days, electric duct insert heaters are used in the air-handling units; and a 720 kw electric boiler with entering water temperature at 110° serves the balance of the system. Two Carrier Model 19C hermetic centrifugal heat pumps are used -- each rated 1044 gpm from 52° to 42° cooling with 1300 gpm condenser water. Power input is 458 kw at rated load. A dry sump cooling tower is used.

37c DESIGN: GAS

Date Bids Received:

Trade	Bid Amount
General Work	$3,302,406.
Heating	535,000.
Ventilating	600,000.
Plumbing	489,700.
Electrical	718,823.
Totals:	$5,645,929.

No. of Bids Taken: 7 (General Work bids included all subcontractors)

Remarks:
Electric Design was Base Bid, Gas Design was Alterante #1.
Site Work (est.) -- $590,000 -- To be done in summer, 1967 and 1968.

Construction Materials:

Floor: 5" concrete on grade; 1-1/2"x2'-0" perimeter insulation; in general resilient tile, but some carpeting, some ceramic tile.
Walls: 4" face brick, 1-5/8" air space, 1-1/2" rigid insulation, 6" concrete block. Field House & Gyp w/ insulated metal wall panels.
Roof: 1" formboard, 2" poured gypsum, 2-1/2" layers of rigid insulation, with built-up roofing.
Ceiling: Suspended acoustical tile.

Glass: Glare reducing glass.
Other: Stack with Gas Design. Boiler Room floor dropped and expanded to accept boilers. No other changes in construction.

Description of Systems:

Service: 480-volt, 3ϕ, 3w from transformer vault outside building; 400A. circuit breaker. Transformation to 120/208-volt.
Lighting: Fluorescent, 70 fc.
Water heating: Gas.
Cooking: Gas and electric.
Incineration: Gas (Future; Separate stack).
Heating, Air-Conditioning: In general, large air supply units with heating and cooling coils and serving distinct areas provide air distribution. Reheat boxes to properly temper the air for each room are located above the corridors.
Other areas utilize force-flow convectors, unit heaters, cabinet convectors, and baseboard radiation. Boilers: Two 350 HP for heating and cooling.
For heating, entering water temperature is at 200°.
For air-conditioning, two Carrier Model 16H absorption machines are used -- each rate 1073 gpm from 52° to 42° cooling with 1760 gpm condenser water. A cooling tower is used.

6. COMPARISON OF CASES

6.1 The Meaning of "Equal" Designs. "Equal" designs prepared by the architects for the seven schools (#31 through #37) for which two proposals were received were considered to be equal on the basis of cost and function analyses prepared by the architect and his engineers. Such cost analyses are ordinarily prepared on a 20-year (or a 30-year) basis, that is: Which system of heating (including all the construction and operating factors inherent in such a system) will have cost the school district the least amount of money after 20-years (or 30-years) of operation?

Construction and Operating factors that must be considered are:

6.1.1 Electricity as the source of energy for heating costs more for the same amount of heat delivered than does natural gas. To compensate for this, school buildings are many times constructed with heavier insulation; thereby reducing heat losses, using less energy, and lowering operating costs. The increased insulation, however, costs more; and a balance must be achieved between higher first cost and lower operating costs. (Increased insulation lowers operating costs regardless of the energy source used for heating).

6.1.2 Natural gas as the source of energy for heating necessitates investment in boiler, piping, ductwork, and pumps -- an investment that may also be present when electricity is used as the source of energy (depending on whether an electric-wet-heat or an electric-air system has been designed); plus an increased investment in electrical service, feeders, and distribution equipment for electrical designs.

6.1.3 Electricity as the source of energy for heating ordinarily decreases the space requirements for boiler, auxiliaries, and piping -- but increases the space requirements for electrical equipment.

6.1.4 Both natural gas and electricity require maintenace/replacement expense: the former on burner, boiler, piping, and pumps; the latter on electrical heating elements and distribution -- and in some cases also on boiler, piping, and pumps.

6.1.5 Custodian, insurance, and miscellaneous electrical energy charges must be considered for both heating systems.

6.1.6 The most desirable energy source for water heating, cooking, and incineration must be studied, as must the cost for provision for future expansion of the school.

After due consideration of all these factors, the architect usually prepares his two design recommendations so that the building construction and heating equipment specified for each will result in installations that will have cost the same amount of money after 20-years (or 30-years).

The Case Histories show how the architect evaluates these factors as they applied to each project. His choices of type and amount

of insulation, type of heating equipment, and allocation of space between service areas and instructional areas were pertinent to his determination that the two designs were "Equal".

6.2 Lighting. Lighting levels in the schools surveyed ranged from 50 to 75 footcandles, fluorescent (see Table 1). Since, in general, higher lighting levels require a greater expenditure for lighting fixtures and wiring; it follows that the more costly the school the higher its lighting levels will tend to be.

A clue to the validity of this premise was investigated in the first report in a study of the statistical association between lighting levels and costs for the elementary schools. Ranking lowest lighting levels with lowest costs, the Rank-Difference Coefficient showed positive correlation for both Cost per square foot and for Cost per classroom with lighting levels; with the Cost per classroom for the nine schools ranked having greater positive correlation with lighting levels than the Cost per square foot.

In other words, for the elementary schools studied, Cost per classroom appeared to be a more accurate index than did Cost per square foot. No such study was made in this report because it was felt that the small number of additional elementary schools studied would add little.

6.3 Water Heating. Based on all the schools considered, this study gives insight into the way in which the source of energy for heating influences the source of energy chosen for water heating.

Quoting from the first report: "With a gas heating design it would design it would seem logical to expect either gas or electricity to be used for water heating (electrical service being brought into the building for light and power) -- the decision being based on engineering factors (such as length of hot water piping runs), economic factors (such as energy cost), and psychological factors (such as familiarity of school officials with one type or another).

"On the other hand, with an electric heating design one would expect that water heating would be electrically operated; since there is no reason for natural gas to be brought to the building."

The small sample of cases included in the first report did not permit verification of these design tenets, but the means for water heating were interesting for the additional questions which arose:

"Considering the eight schools for which two heating designs were prepared (#1 through #8): in the electric designs seven specified electric water heating, one specified gas water heating. In the gas designs the circumstances were just reversed: seven schools were with gas and one was with electricity, although one of those with gas used electric heaters locally mounted at certain isolated locations.

"In the electric-only design schools (#9 through #17), water heating

Table 1 -- Comparison of Facilities

School	Lighting[0] (foot-candles)	Water Heating		Cooking		Incineration	
		Electric Design	Gas Design	Electric Design	Gas Design	Electric Design	Gas Design
#31	50	Gas[2]	Gas	None	None	None	None
#32	50	Gas[3]	Gas[3]	None	None	None	None
#33	50	Gas[2]	Gas[2]	Gas	Gas	Gas	Gas
#34	70	Electric	Gas	Electric	Electric	None	None
#35	70	Electric	Gas	None	None	Gas	Gas
#36	70	Electric	Gas	Electric	Electric	None	Gas[1]
#37	70	Electric	Gas	Electric & Gas 4	Electric & Gas4	Gas[1]	Gas[1]

Notes:
0- In classrooms (fluorescent)
1- Future -- not in original design
2- Electrical heaters were used for lavatories in toilets
3- Existing facility to which connections were made for this project
4- Ranges were gas, other cooking facilities were electric.

was also not electric for all schools: two of the nine were gas-fired (in one of the two gas was also used for incineration)".

Of the seven additional schools studied in this report (#31 through #37): in the electric designs four specified electric water heating and three specified gas water heating, while in the gas designs all seven specified gas water heating (see Table 1).

However, of the three gas water heating in the electric designs, one was so because the school was an addition to existing construction and connections to existing hot water heating systems were made, while the two remaining gas installations had electric water heaters in lavatories.

For the fifteen schools studied to date (#1 through #8 and #31 through #37), therefore, it appears that the conclusion of the first report is valid:

"These circumstances suggest that consideration other than energy source for heating may require both electric and gas services to be run to the building."

6.4 Cooking. In the fifteen schools for which both electric and gas heating designs were prepared, cooking does not appear to be influenced as much as water heating by the energy source specified for heating, although (again) the number of cases is not significant (see Table 2a).

Table 2a -- Cooking in Schools

Schools	Number of Schools					
	Electric Heating Design			Gas Heating Design		
	Electric	Gas	No	Electric	Gas	No
#1 through #8	3	1	4	2	2	4
#31 through #37	2-1/2	1-1/2	3	2-1/2	1-1/2	3

The schools utilizing gas cooking with electric heating also had gas brought into the building for water heating. Many of the cooking facilities (especially in the elementary schools) were "PTA-type" rather than "Cafeteria type".

6.5 Incineration. Incineration for the fifteen schools for which both electric and gas designs were prepared showed almost no influence of energy source for heating on type of incineration: if incineration was deemed necessary, gas was brought into the building. The only exception was in School #36 where future incineration was planned if gas was to be the energy source for heating.

Table 2b -- Incineration in Schools

Schools	Number of Schools					
	Electric Heating Design			Gas Heating Design		
	Gas	Gravity	None	Gas	Gravity	None
#1 through #8	4	1	3	4	1	3
#31 through #37	3	0	4	4	0	3

6.6 Provisions for Future. In the first report all schools studied were evaluated for provisions for future expansion (in electric service and in boiler capacity, where pertinent) and for electric service for future air-conditioning. The conclusion was:

"Comparing provisions for future expansion (electric service and boiler capacity) with building costs (on both cost per square foot and cost per classroom bases), the high cost schools had such provisions built-in (in general), while the lower cost schools did not."

Provisions for Future were not studied for this report, because it was felt the conclusions would add nothing of importance.

7. SUMMARY OF COSTS

7.1 Cost data given in the Case Histories has been collated into tables for purposes of quick comparison. The following are inherent in the listing of the data and important to an understanding of the comparisons developed:

7.1.1 Costs are as bid by contractors of the various trades and are for building and fixed equipment only. Cost of other equipment and professional fees are <u>not</u> included. Site work may or may not be included in the bids and is, in most cases, so identified in the Case Histories.

7.1.2 "Cost per square foot" figures have been calculated from total cost of bids and from total area of building, as given in the Case History for each school.

7.1.3 "Cost per classroom" figures have been calculated from total cost of bids and from number of classrooms, as given in the Case History for each school. Number of additional rooms in the school have <u>not</u> been included in the number of classrooms even though they may at times fulfil the function of a classroom, e.g., multi-purpose rooms, shops, academic activity rooms, music rooms, gymnasiums, speech rooms, library.

7.1.4 "Cost per student" figures have been calculated from total cost of bids and from number of students, differing from the first report where the number of students was arbitrarily set at thirty per classroom. In the first report, therefore, "Cost per student" was related to "Cost per classroom"; while in this report "Cost per student" is an independent measure.

7.1.5 Because of the functional and operating differences between the three types of schools studied (elementary, junior high, high), comparisons between schools should be made only within one particular type, e.g., two elementary schools may be compared, but an elementary school should not be compared with a high school.

7.1.6 Any comparisons made should be with full recognition of the small number of cases studied. All conclusions in this report have been made with this in mind.

7.2 In "Table 3 -- Comparative Cost Data -- All Schools Surveyed" are tabulated all significant cost figures developed from the Case Histories ("Cost per square foot", "Cost per classroom", "Cost per student") for each school surveyed.

Table 3 -- Comparative Cost Data — ALL SCHOOLS SURVEYED[1]

School	Type	Notes	Heating, Air-Condit.	Area (Sq.Ft.)	Number Classrms.	Cost/Sq. Ft.		Cost/Classroom		Cost/Student	
						Electric	Gas	Electric	Gas	Electric	Gas
#31 Virginia Lake	E	2	H	48,142	25	$ 12.53	$ 12.83	$24,133	$24,715	$ 838	$ 858
#32 Sycamore	H	3,4	H	71,457	8	16.88	16.74	--	--	--	--
#33 Long Beach	E		H	28,834	15	16.83	16.03	32,348	30,819	1155	1101
#34 Spaulding	E		H	32,850	20	15.65	15.54	25,709	25,529	734	729
#35 Helen Keller	JH		H AC	64,849	20	15.90	15.46	51,570	50,126	1146[5]	1114[5]
										859[6]	835[6]
#36 Tinley Heights	E		H	24,480	14	12.58	12.23	21,993	21,393	440	428
#37 Glenbard North	H		H AC	304,000	65	18.71	18.57	87,509	86,860	2844[7]	2823[7]
										1896[8]	1882[8]

Notes:
1- Interpret these data in accordance with the text of the report.
2- Part Basement.
3- Addition to existing building.
4- Cost per Classroom & Cost per Student figures not applicable because building is to be used by students in existing facilities.
5- 900 Students.
6- 1200 Students in future.
7- 2000 Students.
8- 3000 Students in future.

The type school (elementary, junior high, high), type design (electric or gas heating, heating-only or heating and air-conditioning), area, and number of classrooms are also listed.

The table encompasses the following range of costs:

	Cost per Sq. Ft.	Cost per Classroom	Cost per Student
Elementary (4 schools)	$12.23 to 16.83	$21,393 to 32,348	$ 428 to 1155
Junior High (1 school)	$15.46 to 15.90	$50,126 to 51,570	--
High (2 schools)	$16.74 to 18.71	--	--

indicating, as in the first report, the wide variation of costs to be expected in school construction, depending on the facilities provided and the design features.

These data are presented in Table 3 to facilitate quick comparisons between electric-design heating and gas-design heating for schools #31 through #37. All data is subject to the limitations of the study as outlined in paragraphs 7.1, above. Further analysis of these figures is given in other sections of the report (but see Tables 4 and 6 and discussions pertinent thereto in paragraphs 7.3 and 7.5, respectively).

7.3 "Table 4 -- Summary of Bidding -- Schools with Both Gas and Electric Designs" compares bidding for schools #31 through #37. Total bids received for all trades are shown for each school for both designs, together with the amount by which the lower bid was lower and the percentage of the lower bid this amount represented.

For the eight possible comparisons (one school had air-conditioning as an alternate) the electric design was lower in cost in one, the gas designs were lower in cost in seven. Percentage by which the electric design was lower was 2.4%. Percentages by which the gas designs were lower ranged from 0.7% to 5%.

7.4 In the first report was shown: "Table 5 -- Comparative Cost Data -- Schools Heated by Gas", which provided significant cost figures ("Cost per square foot", "Cost per classroom", and "Cost per student") for eight schools for which the heating design was gas only -- no electric design having been made.

Table 4 -- Summary of Bidding				SCHOOLS WITH BOTH GAS AND ELECTRIC DESIGNS					
	School	Type	Heating, Air-cond.	Total Bids (all trades)		Lower Cost Design			Design Selected for Construction
				Electric Design	Gas Design	Design	Amount	%	
#31	Virginia Lake	E	H	$ 603,329	$ 617,887	Electric	$14,558	2.4%	Electric
#32	Sycamore	H	H	1,205,961	1,196,544	Gas	9,417	0.8%	Gas
#33	Long Beach	E	H	485,215	462,287	Gas	22,928	5.0%	Gas
#34	Spaulding	E	H	514,178	510,577	Gas	3,601	0.7%	Electric
			H,A	513,978	511,327	Gas	7,651	1.5%	(See Note 1)
#35	Helen Keller	JH	H,A	1,031,381	1,002,515	Gas	28,866	2.9%	Gas
#36	Tinley Heights	E	H	307,900	299,499	Gas	8,401	2.8%	Gas
#37	Glenbard North	H	H,A	5,688,072	5,645,929	Gas	42,143	0.8%	Gas

Notes:
1- Air-conditioning not accepted.

These data were presented as a further basis for comparison with schools heated with two designs or electrically-only. The reader is referred to the first report for further data on this point. Table 5 is omitted from this report in order to keep all tabular data with the same reference number.

7.5 "Table 6 -- Summary of Costs -- Elementary Schools -- Heating Only" summarizes significant data presented in Table 3 ("Cost per square foot", "Cost per classroom", and "Cost per student") for elementary schools in both reports (Phase I and Phase IA).

7.5.1 In Phase I for the five elementary schools bid out to both designs (see Table 6), the mean "Cost per square foot" was $13.78 for the electric design and $13.76 for the gas design. The mean "Cost per classroom" was $25,558 for the electric design and $25,503 for the gas design. The mean "Cost per student" was $852 for the electric design and $850 for the gas design. These means express the conclusion reached in Phase I: "there was no significant first-cost difference between schools designed for electric-heating and for gas-heating."

7.5.2 In Phase IA for the four elementary schools bid out to both designs (Table 6), the mean "Cost per square foot" was $14.40 for the electric design and $14.16 for the gas design. The mean "Cost per classroom" was $26,046 for the electric design and $25,614 for the gas design. The mean "Cost per student" was $792 for the electric design and $779 for the gas design. Again, these means express the conclusion: "there was no significant first-cost difference between schools designed for electric-heating and for gas-heating."

Of some interest was the per cent difference by which gas designs were lower than electric designs: in the first report the mean differences in favor of gas were 0.1% to 0.2%, depending on the cost-measure under consideration. This percentage increased to 1.7% in this latest study, making the weighted difference for all schools (both phases) about 0.9%. The author doesn't feel at this point that inference should necessarily be drawn showing that the differences are increasing in favor of the gas designs: as stated in the first report, these differences do not have significance for the following reasons:

"a. The number of schools available for the study is small." (Bearing in mind, of course, that all schools available for study were included).

"b. Different architect/engineer teams were responsible for the designs represented. Architects' designs are as individual as the architects themselves. Engineers' solutions to design problems are as varied as the problems themselves.

Table 6 -- Summary of Costs		ELEMENTARY SCHOOLS--HEATING ONLY					
Schools Bid Out With Both Electric & Gas Designs		Cost/Sq.Ft.		Cost/Classroom		Cost/Student	
		Electric Design	Gas Design	Electric Design	Gas Design	Electric Design	Gas Design
Phase I Report, January, 1965	Elementary Schools (5 schools) #1, 2, 4, 7, 8	$13.78	$13.76	$25,558	$25,503	$852 (1)	$850 (1)
	Percent By Which Lower Cost Is Low	--	0.1%	--	0.2%	--	0.2%
Phase IA Report July, 1967	Elementary Schools (4 schools) #31, 33, 34, 36	$14.40	$14.16	$26,046	$25,614	$792 (2)	$779 (2)
	Percent By Which Lower Cost Is Low	--	1.7%	--	1.7%	--	1.7%
Phase I & IA Reports Together	Elementary Schools (9 schools) #1, 2, 4, 7, 8, 31, 33, 34, 36	$14.06	$13.94	$25,775	$25,552	$825 (3)	$818 (3)
	Percent By Which Lower Cost Is Low	--	0.9%	--	0.9%	--	0.9%

(1)- At average of 30.0 students/classroom.
(2)- At average of 35.75 students/classrocm.
(3)- At average of 32.55 students/classroom.

"Each is an expert in his area; each includes in his work his own concepts and experiences in esthetics, materials, and building layout; each emphasizes elements that are to him most valid within the scope of the project in meeting the requirements. The first-cost figures reflect these individual differences in technique and approach to a project -- indeed these individual differences are the reasons architects are chosen for projects -- and they are what makes present-day design the vital, meaningful thing it is!"

"c. Space and budget requirements were not identical for all schools."

7.6 Due to the higher cost of electrical energy, some of the architects for the schools studied added extra insulation to the Electric Design schools in order to make the operating costs more comparable. The cost of the added insulation includes, of course, compensatory decrease in size of heating plant.

The Case Histories show how the extra insulation affected construction costs (see "Table 7 -- First Cost Difference vs. Insulation Costs -- Heating Only"):

7.6.1 Of the five schools for which no change was made in construction (one Electric Design was lower in cost, four Gas Designs were lower in cost), the <u>average</u> percent by which the "lower cost" designs were lower was:

Electric Design	1.6%
Gas Design	1.7%

In other words, there was no noticeable cost difference between Electric and Gas Designs when construction was exactly the same.

7.6.2 Of the ten schools for which additional insulation <u>was</u> added (five Electric Designs lower in cost, five Gas Designs lower in cost), the <u>average</u> percent by which the "lower cost" designs were lower was:

Electric Design	1.9%
Gas Design	3.4%

In other words, for the schools studied, Gas Design schools were lower in cost when additional insulation was added to the Electric Design schools -- thereby suggesting that the net change for the additional insulation adds to the total cost, on the average, about 1.5% (3.4% minus 1.9%).

7.6.3 This 1.5% cost differential for increased insulation (and decreased size of heating plant) leads to the following question:

Table 7 -- First Cost Difference vs. Insulation Costs -- Heating Only

School	Insulation the Same For Both Designs			Insulation Added for Electric Design		
	Lower Cost Design	Percent Lower		Lower Cost Design	Percent Lower	
# 1				Gas		6.2%
2				Electric	2.0%	
3				Electric	1.7	
4	Electric	1.6%				
5				Gas		4.5
6				Electric	1.5	
7	Gas		0.3%			
8				Electric	2.0	
31				Electric	2.4	
32				Gas		0.8
33				Gas		5.0
34				Gas		0.7
35	Gas		2.9			
36	Gas		2.8			
37	Gas		0.8			
Averages	Electric	1.6%		Electric	1.9%	
	Gas		1.7%	Gas		3.4%

"First Cost" is complete building construction cost for all trades.
See Text of Report for Discussion.

Does the net energy operating cost differential between electric and natural gas amortize the increased first cost over the economic life of the building -- bearing in mind that Gas Design energy costs would also be decreased if extra insulation were added?

The number of schools available for study to date is, as was previously pointed out, too small for definitive conclusions; and further study of this point as data accumulates will be of great interest.

8. DISCUSSION

8.1 No discussion has been given in the report concerning the wide range of time encompassed by the cost figures given (1958 to 1967 for both reports), and the effect of the yearly increases in building costs on the cost comparisons presented.

In the first report building cost indices for the Chicago area for the construction periods encompassed by the schools built were utilized in comparing costs for "Cost per square foot" and "Cost per classroom."

As explained then, adjusted costs thereby computed were not presented as a part of the final data because all schools are not necessarily in the same labor cost area and different areas may have experienced cost increases at different times and because all bidding dates were not available.

Such adjustments were not made in this study for the same reasons.

8.2 Various design and operating features noted in the Case Histories concern amount of fresh air that can be brought into the classrooms, contribution of lighting and people in offsetting heat losses, individual control of each area, and other similar considerations. These factors are important to the design of the heating systems and were undoubtedly instrumental in the final design selection in accordance with the decisions of the architect and engineer as being applicable to the project in question.

All schools in this study came under provisions of the January, 1964, State of Illinois standard: "Efficient and Adequate Standards for the Construction of Schools", Circular Series A, N. 156, and must, therefore, be considered as being identical as regards minimum standards of lighting, ventilation, and methods of calculating heat losses.

8.3 All schools for which Case Histories were prepared were designed by an architect/engineer team to meet specific requirements of esthetics, space, budget, and construction timing and scheduling. Details of those requirements are not within the scope of this study, and no evaluation of how well the requirements were met in each case is intended or implied.

8.4 The author wishes again to take an opportunity to thank each architect and engineer who gave his valuable time in providing information for this study and hopes that the information and conclusions will be of value.

9. INDEX TO TABLES

10. APPENDIX

a. A copy of the Questionnaire as described in paragraph 4.

b. A copy of the Release Form as described in paragraph 4.

Date_____

Frank R. Valvoda, P.E.
FRANK R. VALVODA & ASSOCIATES
Consulting Engineers
256 Lake Street
Oak Park, Illinois 60302

The attached transcription of your: "Questionnaire -- Comparison of Gas and Electric Heating Systems -- Schools --. First or Construction Cost Only", which we completed together on _____ is in accordance with our conversations at that time, except as noted. We have marked our copy to agree with the one we are returning herewith.

As we discussed during our meeting, you may use this data as you see fit in connection with your report for the Northern Illinois Gas Company.

We understand that we shall receive copies of the report for our own use.

Signed_____

Date_____

Frank R. Valvoda, P.E.
FRANK R. VALVODA & ASSOCIATES
Consulting Engineers
256 Lake Street
Oak Park, Illinois 60302

The attached transcription of your: "Case History -- Comparison of Gas and Electric Heating Systems -- Schools --. First or Construction Cost Only", which we discussed together on July 10, 1967, is in accordance with our conversations at that time, except as noted. We have marked our copy to agree with the one we are returning herewith.

As we discussed during our phone call, you may use this data as you see fit in connection with your report for the Northern Illinois Gas Company.

We understand that we shall receive copies of the report for our own use.

Signed_____

CASE HISTORY -- SCHOOLS
Comparison of Gas and Electric Heating Systems -- First Cost Only

School:

District:
Superintendent:

Description of Building (as built or to be built):

Size:

Classrooms:

Students:

Other Rooms:

Completion Date:

Architect:

Engineer,

Engineer,

Remarks:

~~GAS~~/ELECTRIC DESIGN - A

Bidding: Date Bids Received:

Trade: Bid Amount: Alternates, Etc: No./Bidders:

General Work:

Heating:

Ventilating:

Controls:

Plumbing:

Electrical:

Site Work:

Miscellaneous:

Fees:

Totals:

Remarks:

Construction Materials: (with sketches as required)

Portion: Description: Guide Type: U-Factor:

Floors:

Walls:

Roof:

Ceiling:

Glass:

Other:

Design Conditions:

Heat loss (btuh): Heat gain (btuh)

Normal degree days:

Ventilation: Ventilation:

Conditions (°F): Conditions:

ELECTRIC DESIGN - B

Description of System:		Size, Type, Manufacturer:
Heating & Ventilating	Central System	
	Electric boiler	Duct insert heater
	Heat pump	Electric furnace
	Off-Peak storage	Control (?)
	In-Space System	
	Copper wire mesh heating panels	Infra-red lamp ceiling heaters/fan units
	Rigid conducting material heat. panels	Cabinet convectors
	Heating cable embedded in plaster or gypsum board	Unit heaters
	Fast-response, high-temperature infra-red heaters	Sill-line heaters
	Conductive glass or fiberglass ceiling heaters	Unit ventilators
	Heating cable, embedded in floor	Wall heaters, radiant
		Wall heaters, with fan
		Wall-insert heaters
		Baseboard heaters
	System:	Heat-of-light
Cooling	Compressor, reciprocating	Absorption
	Compressor, hermetic	Heat pump
	Compressor, centrifugal	Source:
	Condenser, water cooled	
	Condenser, air cooled	Package unit (roof, window, other)
	Cooling tower:	
	System:	
Controls:	Electric	Pneumatic
	Description and features:	

~~GAS~~/ELECTRIC DESIGN - C

Lighting:

Room or Function	Type	Level (fc)	Watts/ft.^{2}	Control

Utilities:

Gas service: Size, type, description

Electric service: Voltage:

Service switch:

Metering:

Service entrance:
(type, size, transformation)

Distribution:
(type, description)

Connected loads: KW BTUH

Heating:

Cooking:

Lighting:

Water heating:

Other:

Totals:

Other services (water, sewers, telephone, etc.)

~~GAS~~/ELECTRIC DESIGN - D

Miscellaneous:	Electric	Gas	Notes, Type, Manufacturer
Water heating			
Cooking			
Incineration			
Water coolers			
Snow melting			

Operating Costs:	Estimated	Actual
Period (date, days)		
Degree days (or other criterion)		
Electric usage		
Rate or schedule		
Gas usage		
Rate or schedule		
Water usage		
Rate or schedule		
Total Cost		

Did utility companies make any estimates?

Are costs (estimated or actual) available for water treating, maintenance, etc?

Remarks:

Information furnished by: Date:

GAS/~~ELECTRIC~~ DESIGN - A

Bidding: Date Bids Received:

Trade:	Bid Amount:	Alternates, Etc:	No./Bidders:
General Work:			
Heating:			
Ventilating:			
Controls:			
Plumbing:			
Electrical:			
Site Work:			
Miscellaneous:			
Fees:			
Totals:			

Remarks:

Construction materials: (with sketches as required)

Portion:	Description:	Guide Type:	U-Factor:
Floors:			
Walls:			
Roof:			
Ceiling:			
Glass:			
Other:			

Design Conditions:

Heat loss (btuh)	Heat gain (btuh)
Normal degree days:	
Ventilation:	Ventilation:
Conditions (°F):	Conditions:

GAS DESIGN - B

Description of System:		Size, Type, Manufacturer:
Heating & Ventilating	Boiler	
	Hot water	Steam
	Warm air furnace	
	Gravity	Forced air
	Space heaters	Baseboard convectors
	Multi-zone unit	Convectors, gravity
	Convectors, forced	Radiators
	Fan-coil	Radiant ceiling
	Unit vent.	Radiant panel
	Unit htr.	Direct-fired heater
	On-site generation	Heat pump
	System:	
Cooling:	Compressor, reciprocating	Absorption
	Compressor, hermetic	Heat pump
	Compressor, centrifugal	Source:
	Steam ejector (thermocompr.)	
	Condenser, water cooled	Package type (roof, window, other)
	Condenser, air cooled	
	Cooling tower	On-site gen.
	System:	
Controls:	Electric	Pneumatic
	Description and features:	

GAS/~~ELECTRIC~~ DESIGN - C

Lighting:

Room or Function	Type	Level (fc)	Watts/ft.^{2}	Control

Utilities:

Gas service: Size, type, description

Electric service: Voltage:

Service switch:

Metering:

Service entrance:
(type, size, transformation)

Distribution:
(type, description)

Connected loads: KW BTUH

Heating:

Cooking:

Lighting:

Water heating:

Other:

Totals:

Other services (water, sewers, telephone, etc.)

GAS/~~ELECTRIC~~ DESIGN - D

Miscellaneous:	Electric	Gas	Notes, Type, Manufactur
Water heating			
Cooking			
Incineration			
Water coolers			
Snow melting			

Operating Costs:	Estimated	Actual
Period (date, days)		
Degree days (or other criterion)		
Electric usage		
Rate or schedule		
Gas usage		
Rate or schedule		
Water usage		
Rate or schedule		
Total Cost		

Did utility companies make any estimates?

Are costs (estimated or actual) available for water treating, maintenance, etc?

Remarks:

Information furnished by: Date: